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Architectural Opportunities Seminar

Edited by F. Alan Taylor



Western Laboratory

Special Publication SP-8R

WESTERN LABORATORY

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Effective April 1, 1979 the Laboratory became a research division of Forintek Canada Corp., a Canadian non-profit corporation.

The Laboratory has a staff of 110 actively engaged in work in a dozen scientific and technical disciplines. It is a problem-oriented organization that offers assistance and expert advice to the forest products industry, professional associations and consultants, provincial and federal government agencies, trade associations, equipment manufacturers, educational institutions and the general public. These services are offered with the objective of realizing the optimum benefit for Canadian society from one of the country's most important natural resources — its forests. The general area of responsibility of the Western Laboratory includes the four western Canadian provinces, the Yukon and Northwest Territories.

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ARCHITECTURAL OPPORTUNITIES SEMINAR –
The Use and Misuse of Wood in Construction and Architectural Design

Edited by
F. Alan Tayelor

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KEYWORDS

wood construction, protection, biological attack, hazards in buildings, wood preservatives, wood foundations, ground contact, moisture in building enclosures.



FOREWORD

On January 9, 1974, the Western Forest Products Laboratory of the Canadian Forestry Service in consultation with the Continuing Education Committee of the Architectural Institute of British Columbia, presented an Architectural Opportunities Seminar, "The Use and Misuse of Wood in Construction and Architectural Design".

The seminar was prompted by incidents of improper use of wood in the Pacific Northwest. An apparent need exists to acquaint architects with the hazards attendant upon the use of wood, to explain how to prevent or forestall the adverse effects of these hazards, and to point out some of the architectural opportunities that wood offers as a building material.

This publication is not in the usual form of an Information Report, but is rather the collected remarks of the speakers at the seminar. Their talks were supplemented by extensive use of visual aids, most of which are not reproduced here. However, it is felt to be a useful document for practicing architects in this informal format.

F. Alan Tayelor
Editor.

INTRODUCTION

The worldwide acceptance of wood as a building material since the beginning of time must be attributed to something more than aesthetic appeal. These extra attributes include its ability to withstand weather in its natural state and, when properly used, its ability to resist destruction by insects and fungi. We, as residents of the producing area for some of the world's finest timber, tend to treat this excellent material rather too casually, and as a result, we often create problems in its application. This is particularly true of areas such as the Pacific Northwest area of North America where timber with ideal properties for structural and aesthetic uses grows in abundance.

In the papers presented, we deliberately concentrate on problems that can arise. Very few architects must be convinced that wood is a useful material aesthetically and structurally, but many architects lack intimate knowledge of many essentially simple facts about wood and its application, that if properly recognized, can prevent many of the problems now encountered in the use of wood.

PRINCIPLES OF BIOLOGICAL ATTACK

Roger S. Smith, WFPL

Without doubt wood constitutes man's most important and valuable, basically non-edible, renewable resource. However, because of the natural development of trees over millions of years, they exist in ecological niches surrounded by millions of other different organisms, both large and very small, all contributing to the overall balance of nature. Wood naturally is biodegradable and without this situation life on the planet would have ceased to exist thousands of years ago. Natural breakdown and subsequent reconstruction is nature's way of achieving ecological stability and provides man with a hospitable place in the universe.

Introduction to the structure of wood

To try and understand how fungi fit into this overall natural plan, some small understanding of the structure of wood is necessary. Woods can be divided into hardwoods and softwoods and, because of the overwhelming importance of softwoods to the west coast situation, a typical softwood structure is described.

The wood cells are mainly made up of the elements carbon, hydrogen and oxygen linked together to form the most important chemical compounds in wood, holocellulose and lignin. Typical softwoods contain about 70 – 75% holocellulose and 25 – 30% lignin on a dry weight basis.

Trees then, by utilizing solar energy, convert the carbon from carbon dioxide in the atmosphere into a natural building material for man. It is now time to see how the process is reversed and how fungi break down the carbon structure of wood, releasing energy as heat and carbon dioxide once more to the atmosphere. It is this natural breakdown process which interests and concerns all those involved in the long-term use of wood and especially those architects concerned in the design of wooden structures. This latter destructive process, a natural function of life, acts against man's requirements for the use of wood. It is the design

methods that you as architects are using today which can protect wood and prevent man from squandering his most valuable natural resource.

Fungal structure, growth and type

Fungi belong to a primitive branch of the plant kingdom. They differ from green plants in their lack of chlorophyll and hence in their inability to manufacture sugars using sunlight, carbon dioxide and water. Therefore, these primitive microorganisms are forced to obtain their food supplies from an external source. Wood can be such a source and fungi can grow on the surface and within wood, using up freely available sugars and breaking down the more solid structure of wood to obtain the less freely available food materials. Fungi grow by the production of narrow tubes, called hyphae, which branch and spread over a suitable substrate secreting chemicals, called enzymes, which dissolve and consume the substrate (Fig. 1). They can reproduce and spread rapidly by producing large numbers of spores of many kinds which can be blown around in the atmosphere, alighting and growing again on any suitable substrate (Fig. 2). This view of fungi is considerably simplified, since thousands of different types of fungi exist, showing different forms of growth, types of reproduction and capacities to attack and colonize wood.

Most fungi have at least the following four basic requirements for growth (Fig. 3):

1. The presence of a suitable source of food;
2. The presence of oxygen;
3. The presence of moisture;
4. The existence of a suitable temperature.

Lack of one of the above requirements will normally prevent the growth of fungi. Therefore, if wood is kept dry, as within a house, no growth of fungi will occur. Also, if logs are kept submerged in water, where oxygen will be severely restricted, little fungal growth will occur.

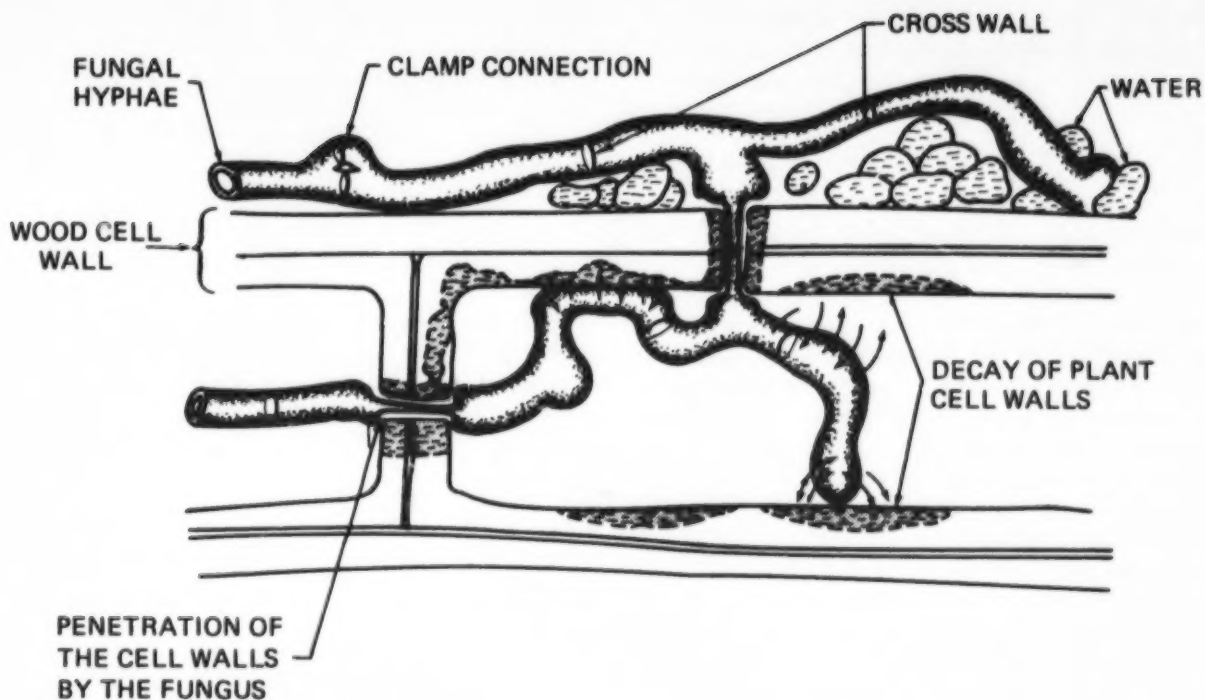


Fig. 1. Stylized figure showing fungal attack of wood cells. Arrows indicate the movement of enzymes outwards and soluble sugars inwards through the cell walls of fungal hyphae.

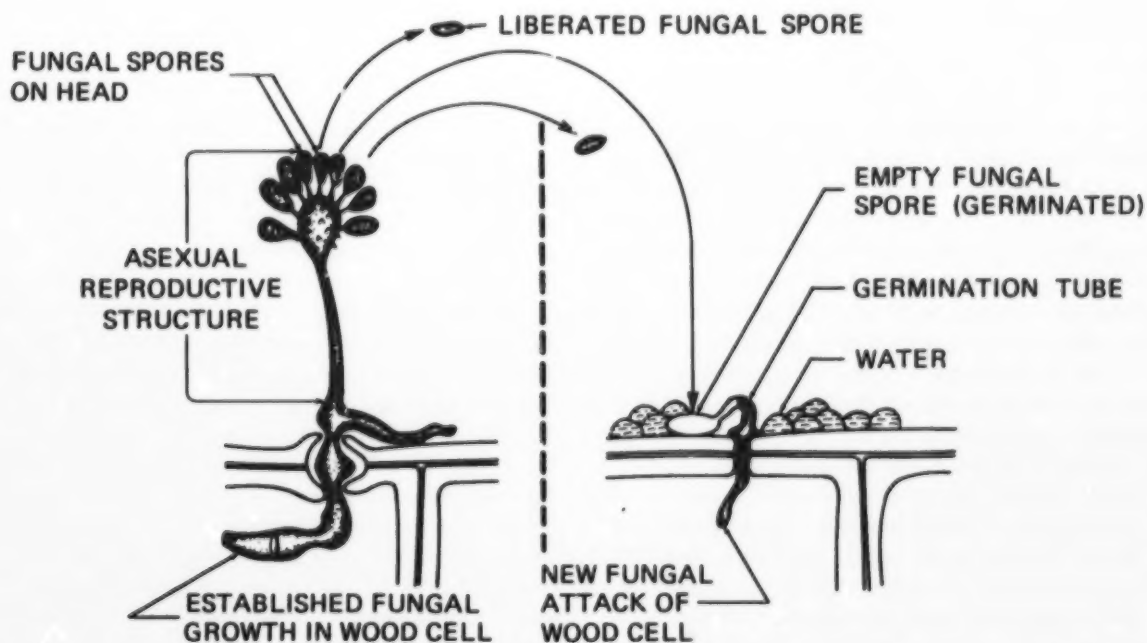


Fig. 2. Stylized figure showing the asexual reproduction and spore dissemination of a simple fungus. A spore is shown germinating and penetrating a fresh wet cell of wood.

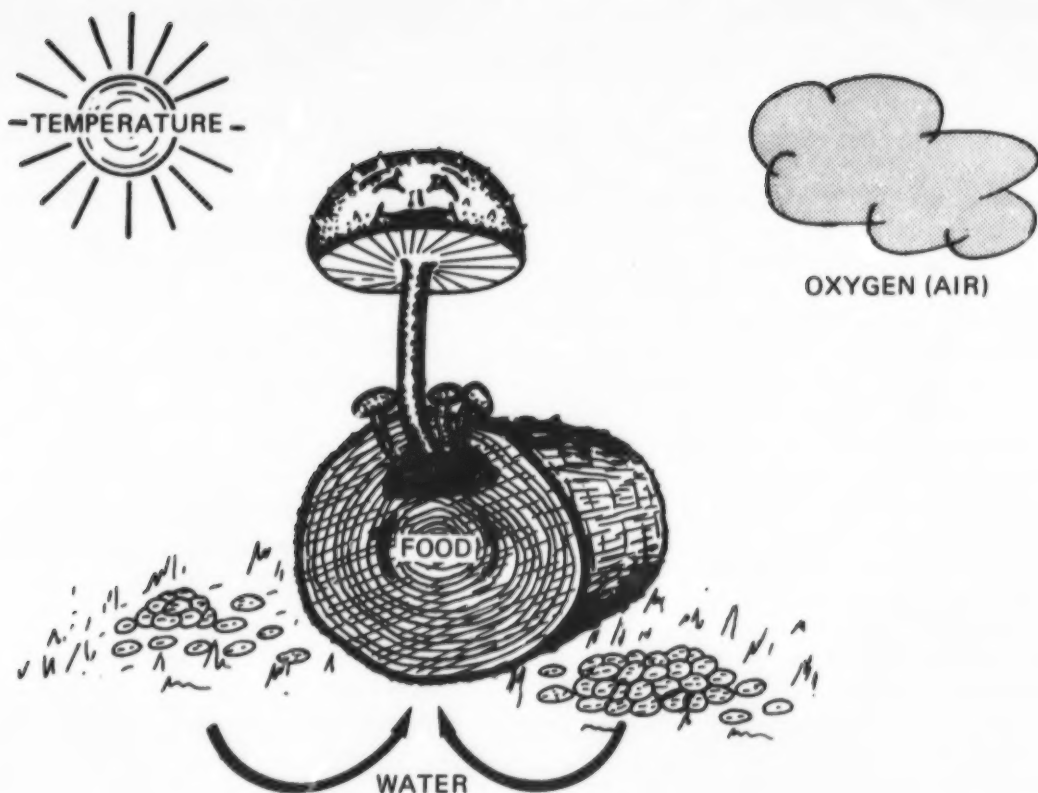


Fig. 3. The four basic requirements for good fungal growth.

The requirements necessary to kill fungi differ from the four previously discussed. Therefore, although fungi may not grow at low temperatures or without the presence of moisture, they do not necessarily die, or if they do it may take many years. For example, viable decay fungi may be present in lumber used for house construction, laying dormant for many years, but subsequently they may resume growth and should the lumber become suitably wetted due to poor house maintenance.

It is convenient to group fungi inhabiting wood into three groups:

1. True wood-destroying fungi

The group includes the more highly developed forms of fungi which have the abil-

ity to rapidly attack and consume lignin and/or cellulose. Fungi which break down lignin and cellulose are called white-rot fungi and those which break down only cellulose are called brown-rot fungi. Considering softwoods, it is the brown-rot fungi which are of greatest importance in decay of building structures. Various descriptive terms, such as pocket rot and laminated rot, are used to describe decays, but these need not concern us at this moment.

When fungi decay wood they can cause the following changes:

- (i) loss in wood weight;
- (ii) loss in wood density;
- (iii) loss in wood strength and toughness;

- (iv) increase in wood acidity;
- (v) increase in wood moisture content;
- (vi) change in wood color;
- (vii) change in wood smell;
- (viii) loss in wood extractives.

From the architectural viewpoint, the effect of reduced strength due to fungal attack is of prime importance. This factor is related to weight loss and duration of fungal attack as shown in Fig. 4.

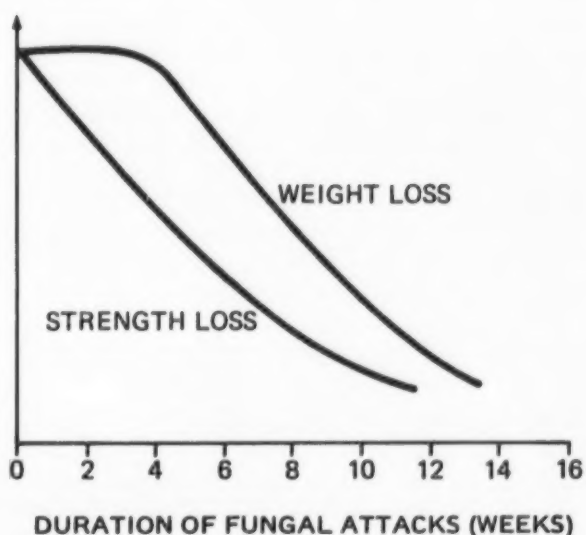


Fig. 4. Losses in wood weight and strength with time during fungal attack.

The impact bending strength (or toughness) of wood is most rapidly affected by fungal attack. For example, one can observe a 95% reduction in toughness with only a 10% reduction in wood weight. Such knowledge is important in the construction of various commodities, like wooden ladders, sports equipment, etc. It is very important to remember that the strength properties of infected wood should not be assumed to be unimpaired, even if the wood is hard and firm. Certainly, if wood-destroying fungi have advanced in a piece of lumber to the extent that they cause

color changes, it is safe to say that some reduction in the strength properties of that wood have occurred.

2. Sapstain fungi

These are fungi which cause unsightly dark brown, blue or black discolorations in lumber, mainly in the sapwood of pieces. Generally little true decay occurs, although stain presence indicates moist conditions in the wood sufficient to support attack by true decaying fungi. Sapstain fungi mainly live on freely available sugars concentrated in the sapwood and they are not capable of attacking cellulose and lignin. Sometimes sapstains or similar dark stains are superficial and can be machined off the surface of wood, but often they may penetrate quite deeply. Bleach solutions can be used to reduce the stained appearance, but generally not without some unsightly changes in the normal natural color of wood.

3. Mould fungi

Mould fungi can cause unsightly discolorations of various kinds, greens, pinks, browns, etc. Again the fungi do not decay wood, but they do indicate conditions favorable for the subsequent development of decay fungi.

One important side effect of sapstain and mould fungi, in particular, appears to be the ability of some of them to break down the extractives in some naturally durable woods. For example, western red and yellow cedar contain chemicals which are toxic to wood-destroying fungi and hence their reputation and widespread use as woods with considerable longevity. However, should certain mould-type fungi colonize these woods, then very rapidly the protective chemicals are broken down and the wood becomes very susceptible to decay. This is probably part of the reason for the frequent catastrophic failures of western red cedar shake roofs, particularly in the wet, high hazard west coast situation of Vancouver.

In summary, it can now be seen how fungi attack and colonize wooden structures. The first and best line of protection remains correct architectural design to prevent the wetting of wood. Should this be difficult or impossible, then some form of chemical protection by the use of suitable wood preservatives is essential. Wooden buildings,

when correctly designed and built, can and have lasted many hundreds of years and, while this may not presently fit in with the current trends of built-in obsolescence, I'm certain that our future thinking must change and we can look forward again to the construction of buildings of lasting beauty and durability.

DECAY HAZARDS IN WOODEN BUILDINGS

J.W. Roff, WFPL

Speaking on hazards in wooden buildings, I assume that we agree that there *are* hazards in wooden buildings, just as we agree that there are hazards in concrete buildings, steel-frame buildings, grass huts and primeval men's caves.

I do not infer that wooden buildings are more hazardous than others and I do not mean to exaggerate the risks of using wood for buildings.

We have seen many cases where the utility and beauty of wood structures have outlasted generations of builders and we have also seen cases where structures have failed before they had served their purpose. My intention is to point out where wood has been misused and where architects should look for ways to correct this fault.

My talk deals with hazards in buildings which relate to wood decay by fungi. Insects are also a concern, but in this climate they are merely a nuisance and seldom cause significant structural damage. Insects which may concern architects here include the carpenter ants, found in foundations, posts and large beams. They are often seen in houses set in forested areas or on newly cleared land. We also have powder-post beetles in old dry beams adjacent to storage areas containing old lumber or firewood. Termites occur here, but they are the dampwood variety, inhabiting partially rotted wood and wood in contact with soil. Drywood, subterranean termites are extremely rare in western Canada.

Requirements for decay

Considering deterioration of wood by fungi in wooden buildings, one should go back to the basic requirements for life of wood-destroying fungi. In simple terms, they need food, water and air. Take away one of these and we achieve preservation of wood. The supply of food is governed by selection of suitable wood species and of suitable types of wood. Water supply, the other requirement which can be easily controlled, is regulated largely in manufacture of lumber and construction of buildings.

(a) Selection of wood

Two main types of wood — sapwood and heartwood — must be recognized by all users concerned with service durability of wood. While both sapwood and heartwood are equally strong and similar in all other respects, sapwood timber, which represents the living portion of a tree, is lacking in decay resistance and, regardless of the wood species concerned, sapwood should be prohibited for use wherever there is risk of decay unless it is treated with a preservative. The heartwood portion of different woods varies in susceptibility to attack by fungi. The wood of trees, such as poplar, alder, western hemlock or spruce, are low in durability and would be expected to decay rapidly if used without preservation for posts, outside steps and decking, etc.; whereas the woods of western red cedar, yellow cedar or redwood are naturally durable and could be expected to have a service life 10 to 15 times longer, when used under the same conditions. In these durable woods, decay resistance is imparted to timber during growth of a tree through deposits of extractives. These are extremely toxic natural preservatives and are much more concentrated in outer heartwood than in wood that is closer to the pith or central portion of a tree; therefore, wood in the pith region is less durable. This explains the common occurrence of hollows in cedar trees and large timbers and also indicates that, if the most durable wood is required, one should avoid timbers containing pith, i.e., "boxed heartwood", and attempt to select timber cut from heartwood at some distance away from the pith.

Selection of timber also is based upon lumber grades. Grading is a means of sorting lumber for end use and the main criterion for most purposes is strength. Different grades of lumber vary in relation to size and type of knots which they permit, also in relation to presence and extent of natural defects, fungal and insect attack. Rot or advanced decay is termed unsound wood in grading terminology and is rigorously excluded from quality struc-

tural material. It should be remembered, however, that rot pockets are surrounded by a region or zone of incipient decay where a causal fungus is advancing through wood, but has not yet reached the rot condition. This early form of decay may be included in some graded timbers and can be accepted provided the wood is firm. Where it is visible as a change in wood color or appearance, early decay is termed heart stain in grading, and it is evidence that a fungus is present. While such wood is often sufficiently strong for the purpose intended, the affected area will be less resistant to subsequent decay in service. Thus, grades of lumber which permit heart stain should be avoided wherever maximum durability is required and where the material will not remain dry.

(b) Presence of moisture

The presence of moisture in wood is really the key to durability of structures. Without moisture supply, even the most decay-susceptible wood can be safely specified for long-term use; but if wood is supplied with moisture, it may fail in a few months. The moisture content of wood may be measured electronically during construction or in service by using a portable meter. Twenty percent moisture in wood is insufficient to support fungal growth, but a serious decay condition can exist in wood of more than 30 percent moisture content. Saturated wood, of course, will contain no air and thus will not support fungi and will not decay. In practice, permanent saturation of wood seldom prevails, but rather there is normally a balance of air and moisture in wood.

As architects, you will understand that unless specified as kiln dried, lumber will likely be supplied in an unseasoned condition having a moisture content often well in excess of 30 percent. It should also be realized that the use of unseasoned lumber not only leads to problems of decay but also to problems in shrinkage and warping of wooden frames and joists, as the material eventually dries inside a building.

Moisture can originate in wood in several ways. It may be a part of lumber as it was sawn from a log and, when used in construction, it may vary from 30 percent m.c. in fresh-cut heartwood up to 100 percent or more in sapwood. In many cases, lumber may arrive at a building site in a dry condition but, if not properly covered and raised off the ground, it may be wetted by rain or snow and have a very high moisture content before finally being used in building. The length of time for lumber to dry varies with its thickness and surrounding atmosphere. Even two-inch-thick lumber in a building may remain wet for many months and thus remain susceptible to decay.

(c) Faulty design, construction and maintenance

Faulty construction and poor maintenance can also be pinpointed as contributors to the misuse of wood. Situations where foundations are too low and soil grading and landscaping result in wood being wetted from contact with moist soil, such as where patios and steps serve to retain rainwater at joints and bearing surfaces, are typical. Window sills and door frames may be recessed so that moisture is led into a building. Roofs may leak because of the tendency to use shorter lengths of shingles or shakes, to decrease the overlap and to reduce the pitch of roofs. Where the slope is low and shingles do not overlap sufficiently, rainwater may be driven upward between the overlapping portion by wind so that water leaks into a building. Moisture in wood that comes from leaking roofs, siding, etc., provides a very hazardous situation because it often occurs intermittently in enclosed wall and ceiling spaces where lack of ventilation delays drying, leaving a favorable air-moisture balance for a fungus.

Faulty design which permits moist, warm air from the living area to escape into cold spaces in walls and attics is another source of moisture in wood which develops through condensation of water on cold surfaces. This problem becomes more acute as insulation materials become more effective and with the installation of such appliances as clothes

washers and driers without providing adequate vents to carry outside moisture from wet clothes.

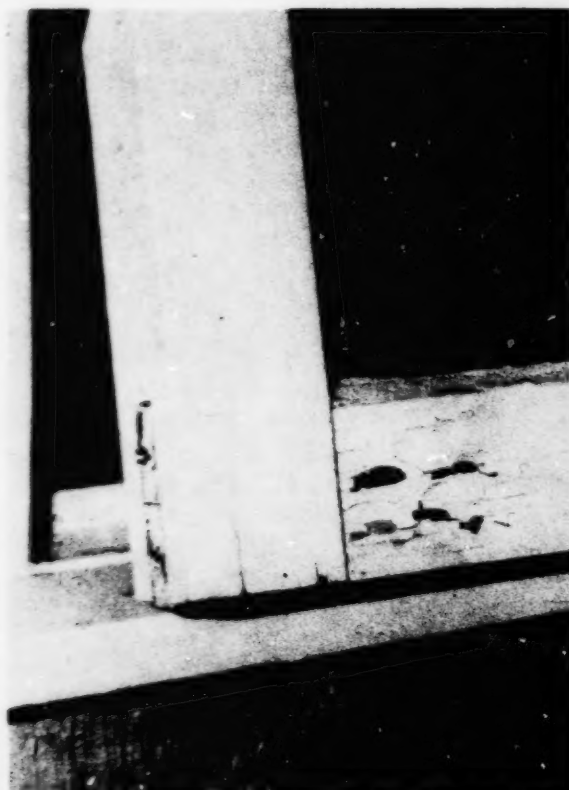
Moisture in wood can develop also in unexcavated parts of buildings, steps and crawl spaces, where moisture from the ground can saturate the air unless soil covers of plastic sheeting or waterproof paper are present. In this situation, the term dry rot is familiar but it is a misnomer as far as fungi in this region are concerned. The term "dry rot" is used here to describe the appearance of the wood after decay is complete and, it must be remembered, decay fungi need moisture to get started as well as a supply of moisture in wood to carry on destruction.



Decay in untreated western red cedar posts after 12 years of service in a sandy soil.

Decay hazards in buildings exist often through poor maintenance of exterior woodwork and lack of caulking at joints. Because of

the tendency for wood to shrink and swell with changes in humidity, gaps may appear where two boards meet. This exposes end grain of wood which absorbs moisture readily and is often the first place to show decay. Fortunately, end grain is also very receptive to preservative treatments and is readily protected from decay by dip treating on the site during construction.



Decay in untreated window sash after 15 years of service. Lack of caulking in mortice and tenon joint and failure of putty seal allowed rain water to penetrate wood.

On exterior woodwork, paint acts as a moisture barrier to reduce the rate of moisture movement in wood. It tends to keep dry wood "dry", but in order to bond properly the wood must first be clean and dry. Painting wet wood makes for a poor bond and results in a partial moisture barrier which reduces subsequent drying and favors decay in wood. Poor paint bonding results in a discontinuous film, through which moisture can penetrate and set up a de-

cay condition in wood behind the paint film. Because of vapor pressure, moisture movement in wood may produce paint blisters which further add to the general deterioration. This is often seen in poorly maintained window joinery, garage doors and siding on houses.



Decay in board and batten siding after six years of service. Lumber was painted while wet.

Many of the problems which we see concern factories and public buildings, where the original structure has been enlarged or otherwise remodeled without regard for the maintenance of ventilation or soil drainage.

Porches, sun decks and loading platforms, originally constructed to be free standing, can become enclosed and sandwiched between new construction and, with no additional allowance for soil cover and ventilation, can be destroyed by rot within a few years.



Decay in an untreated 4 x 4 post, which was dapped to support a 2 x 6 joist in a sundeck, after eight years of service. Rain ran down the post and was trapped in end grain supporting the joists which also were decayed.



Decay in an untreated 2 x 6 joist in service for four years. It was nailed to an untreated post set in the ground.

Another common situation occurs when, during renovation of a building, a rough concrete floor is covered with a wooden floor. Without provision for a vapor barrier and adequate space for ventilation, decay in untreated wood can be rapid. A recent case involves 3000 square feet of luxury offices and showcases,



Decay in an untreated 6 x 6 post after 12 years in service set directly on a concrete floor in a carport.

where 100 feet of floor space has already failed in just three years. Because the renovation design did not permit cross ventilation under the flooring, the entire area will now have to be replaced using treated wood sleepers on a vapor-sealed concrete floor.

SUMMARY

In addition to provision of sufficient strength, the correct use of wood in buildings entails assessment of decay hazards and selection of materials of adequate durability. Where exposure to weather and contact with soil cannot be avoided, preservative-treated wood should be specified for maximum service life. Untreated heartwood of durable species may be used in these situations, but it will lead to a shorter useful life of the structure.

In specifying the best type of material, the grade of lumber should prohibit insect and decay damage and the wood should be dry before it is enclosed in a building. This means that it must be protected against rain at a building site.

In building design, footings must be raised clear of soil; roof siding and openings for doors and windows must shed water. Moisture barriers and ventilation inside the structure must be designed to avoid high humidities in enclosed spaces. Where one of these requirements cannot be met, consideration must be given to using preservative-treated lumber to obtain maximum service life of buildings.

USE OF WOOD PRESERVATIVES TO PROTECT WOOD IN SERVICE

P.A. Cooper, WFPL

INTRODUCTION

Untreated wood may be used safely in many areas in a building, providing it is properly designed and constructed to ensure that the moisture content stays at less than 20 percent. When a building's moisture content rises above this critical level, wood must be reinforced with a chemical preservative to ensure a satisfactory service life. This is achieved by forcing preservative solutions which are toxic to decay fungi and insects into the cellular cavities of wood.

Preservative treatment adds to the cost of wood, which presents a designer with the problem of convincing his client that the added expense is justified. For wood used in high-decay-hazard areas, as in ground contact, untreated wood can decay in as short a time as one year and the treating cost is trivial compared with repair and replacement costs. It is more difficult to justify the cost of treating wood not in ground contact. In Britain, however, local and national building authorities have recognized the economic importance of decay prevention and most building timbers and joinery are now given some chemical treatment. When the high costs of wood and of labor required to install, repair or replace it are considered, it seems evident that Canada will also eventually adopt similar procedures. Western red cedar shakes and shingles are examples of products for which preservative treatment can be justified, although they are not usually treated at present. In high-rainfall areas, the leaching out and breakdown of the fungitoxic extractives by water and non-decay organisms may permit decay fungi to become established in untreated shakes in 10 to 15 years. We anticipate that by treatment with a suitable preservative solution, adding only 20 - 30 percent to the original cost of the wood, the service life will be more than doubled. In addition, unsightly moss and mildew will also be controlled.

WOOD PRESERVATIVES

Ideally, preservative treatments should not impart undesirable properties to wood. One concern is that treated wood be as safe to handle and to be in close contact with as untreated wood. This condition is met with most preservative solutions, as only small amounts of preservative are required in wood and the chemicals are relatively stable and permanent in wood. Other properties, such as cleanliness, paintability and color, may be affected by the preservative.

Some of the properties, approximate costs and sources of supply in western Canada of the common preservatives are given below. All treaters use pressure methods except those designated "thermal".

Creosote, Creosote-Petroleum Mixtures

Advantages:

- Effective against decay, insects and most marine borers
- Stable in wood with low leachability and volatility.

Disadvantages:

- Black color, non-paintable, dirty, smelly and difficult to work with.

Approximate cost:

- \$.85 - \$1.00 per cubic foot
- \$90 per M fbm of lumber.

Treaters:

- Canada Cedar Pole Preservers Ltd., Galloway, B.C. (thermal)
- Domtar Chemicals Ltd., New Westminster, B.C.
- Domtar Chemicals Ltd., Cochrane, Alta.
- Domtar Chemicals Ltd., Edmonton, Alta.
- Domtar Chemicals Ltd., Transcona, Man.

- Koppers International Canada Ltd., Burnaby, B.C.
- Northern Wood Preservers (Sask.) Ltd., Prince Albert, Sask.

Pentachlorophenol-in-oil

Advantages:

- Effective against decay and insects
- Stable in wood
- Lighter in color and cleaner than creosote.

Disadvantages:

- Non-paintable, not effective against marine borers
- Possible future restrictions on use for environment reasons.

Approximate cost:

- \$.85 - \$1.00 per cubic foot
- \$80 per M fbm of lumber.

Treaters:

- Bell Pole Co. Ltd., Lumby, B.C. (thermal)
- Branch Pole Co. Ltd., Edson, Alta.
- Canada Cedar Pole Preservers Ltd., Galloway, B.C. (thermal)
- Domtar Chemicals Ltd., New Westminster, B.C.
- Domtar Chemicals Ltd., Prince George, B.C.
- Domtar Chemicals Ltd., Cochrane, Alta.
- Domtar Chemicals Ltd., Edmonton, Alta.
- Domtar Chemicals Ltd., Prince Albert, Sask.
- Domtar Chemicals Ltd., Transcona, Man.
- Dura Wood Preservers, Surrey, B.C.
- Koppers International Canada Ltd., Burnaby, B.C.
- Lehner Wood Preservers, Prince Albert, Sask.

- L. & M. Wood Products Ltd., Glaslyn, Sask.
- Natal Forest Products Ltd., Coleman, Alta.
- Northern Wood Preservers (Sask.) Ltd., Prince Albert, Sask.
- North-West Wood Preservers Ltd., Dawson Creek, B.C.
- Peerless Wood Preservers Ltd., Cayley, Alta.
- Rocky Wood Preservers Ltd., Rocky Mountain House, Alta.
- Silvican Resources Ltd., Lovell Cove, B.C.

Pentachlorophenol-in-Fugitive Solvent

Advantages:

- Paintable, clean, colorless

Disadvantages:

- Expensive, may not be as effective as oil-borne pentachlorophenol in ground contact

Approximate cost:

- \$200 per M fbm (Cellon), \$125 per M fbm (Dow)

Treaters:

- McCormick and Baxter, Portland, Oregon (Cellon)
- Domtar Chemicals Ltd., Trenton, Ontario (Dow process)

Chromated Copper Arsenate (CCA)

Advantages:

- Clean, paintable, uniform light green color, fixed in wood, effective against decay and insects

Disadvantages:

- Wood must be seasoned twice, large timbers check badly on redry, supports glowing combustion

Approximate cost:

- \$55 — \$85 per M fbm

Treaters:

- B.C. Clean Wood Preservers Ltd., Surrey, B.C.
- Cote Wood Industries, Kamsack, Sask.
- Koppers International Canada Ltd., Burnaby, B.C.
- Prendeville Timber Preservers Ltd., Neepawa, Man.
- Roblin Forest Products Ltd., Roblin, Man.

Approximate cost:

- \$75 per M fbm

Treaters:

- Domtar Chemicals Ltd., New Westminster, B.C.
- Domtar Chemicals Ltd., Edmonton, Alta.

Fluor-Chrome-Arsenate-Phenol (Tanalith, FCAP)

Advantages:

- Clean, paintable, effective against decay and insects

Disadvantages:

- Wood must be dried twice, not recommended for ground contact

Approximate cost:

- \$75 per M fbm

Treaters:

- Koppers International Canada Ltd., Burnaby, B.C.

Ammoniacal Copper Arsenite (Chemonite, ACA)

Advantages:

- Clean, paintable, fixed in wood, good penetrating properties, effective against decay and insects

Disadvantages:

- Somewhat mottled blue-green color, wood must be seasoned twice

The use of the above preservatives is usually restricted to commercial treating plants. There are several preservative solutions available in small quantities to homeowners or builders from hardware or building-supply stores. These include creosote, pentachlorophenol, copper naphthanate and zinc naphthanate thinned with mineral spirits or other penetrating solvent.

METHODS OF TREATING

Pressure Impregnation

The most effective treating method is to force preservative solution into wood in a large pressure vessel or retort at pressures up to 150 psi. A preliminary vacuum may be applied to remove

air from wood cell cavities so the preservative can saturate the wood, called a "full-cell" treatment. Alternatively, an empty-cell process may be used where the air is left in the wood, or in some cases the wood is pressurized with 25 – 75 psi of air before the preservative is admitted to the retort and pressure applied. Air is compressed in the wood during treatment and, when the pressure is released, "kicks back" much of the preservative, leaving the internal surfaces of the wood only lightly coated with preservative. Thus it is possible to specify the level of treatment to suit the degree of decay hazard for the intended use of the wood.

Thermal or Hot-and-Cold Bath Process

Wood is placed in a hot preservative bath for several hours to drive the air from the wood and then placed in a cold preservative bath. As the air contracts and water vapor condenses on cooling, preservative is drawn into the wood. This process is less costly than pressure impregnation, but it is also less effective; in addition, levels of treatment cannot be closely controlled and it is presently used only with oil-borne preservatives.

Other Treatments

Some degree of protection can be imparted to wood by cold soaking, by dipping or by brush treatments. However, the penetration is limited and the treatments are not effective under high decay-hazard conditions.

Required Level of Treatment

Long-term service records have shown which levels of treatment are generally required for various uses. These are given by the Canadian Standards Association (CSA). Specifications as preservative penetration and concentration requirements for wood used above ground, in ground contact, in marine environments and in preserved wood foundations, a particularly high decay-hazard ground-contact use.

Ensuring Integrity of Treatment

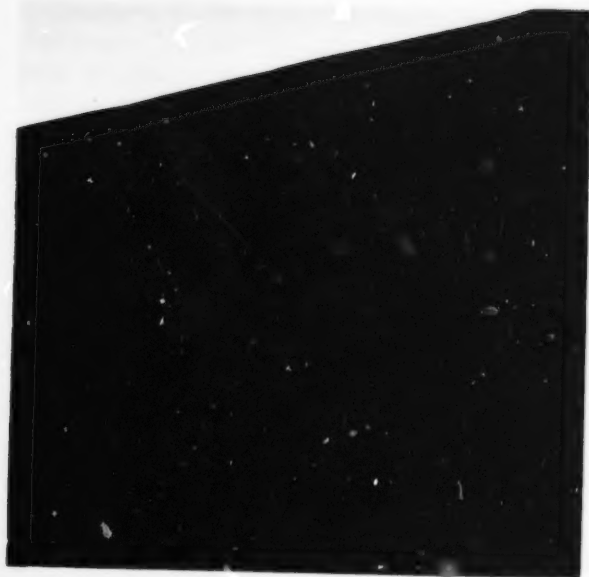
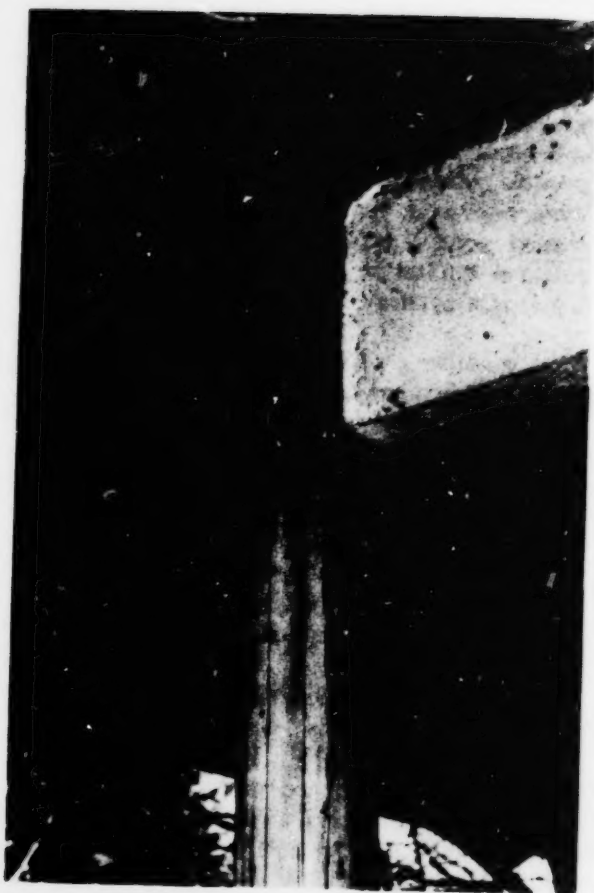
Unfortunately, adequate protection of wood is not always ensured by treating to the CSA speci-

fied levels. One problem occurs when alterations, e.g. cutting or drilling, are made on treated wood at a building site. If conditions are favorable for fungal growth and untreated wood is exposed, it will become infected in a short time. Thus, where possible, all timbers should be cut to proper dimensions and framed before treatment. If untreated wood is exposed, it must be protected by a liberal application of preservative in a penetrating solvent applied on the site during construction.

Another problem is that wood can be, and often is, treated at a higher moisture content than it will eventually reach in service. As the wood dries, it shrinks and checks or cracks open. In large timbers, the checks may extend through the treated layer of wood, trapping moisture and fungus spores, so decay starts in the exposed untreated wood. Ideally, this problem should be avoided by specifying that the wood be seasoned to the expected service moisture content before treating. This is seldom practical, especially for large timbers. An alternative is to control after-checking through pretreatments. One possible method, applicable to sawn or round timbers, is to kerf the wood before drying and treating. A saw cut is made along the timbers, extending to the pith. As the wood shrinks, the kerf widens to relieve the drying stresses, but since it does not deepen beyond the pith no untreated wood is exposed. This approach is presently being used for transmission poles in Oregon and for cabin logs in central and northern British Columbia. An example of the use of kerfed posts can be seen at the Japanese (Nitobe Memorial) gardens on the University of British Columbia campus in Vancouver.

Also, incising sawn or round timbers, i.e., mechanically puncturing the surface with many 3/8- to 3/4-inch-long teeth, improves the service life of large timbers. Incising not only promotes a deeper and more uniform penetration of preservative, but results in a more uniform checking pattern, with many small shallow checks through the incisions instead of a few deep ones.

If these problems are recognized and taken into account, treated wood will give a long service life.



Kerfed posts in the tea house of the Nitobe Memorial Garden, University of B.C., Vancouver.

Remedial Treatments

If decay is established in a building, it is difficult to eradicate. The best approach is to find the source of the problem — the conditions permitting the moisture to collect in the decaying area — and to remedy it. If the decay has progressed too far, the infected wood will have to be replaced.

Chemical treatments may be helpful in some cases. Shallow surface infection by decay fungi, sapstain or mould organisms can be stopped through brush application of a preservative in a penetrating solvent. However, the chemical will not penetrate more than 1/16 inch in the side grain, and deeper infection will not be controlled. Sur-

face discoloration can be bleached with hydrogen peroxide or household bleach.

Deep internal decay, as for example decay started in the bottom of a deep crack in treated or untreated wood, cannot be stopped with conventional preservatives. One possible procedure, still in the experimental stage, is to inject high-vapor-pressure toxic chemicals or fumigants into the decaying area; the vapor diffuses through the wood sterilizing it. Preliminary studies indicate that wood provides enough resistance to vapor movement to confine it for several years, thereby preventing reinfection for some time.

GROUND CONTACT AND WOOD FOUNDATIONS

F. Alan Tayelor, P. Eng., WFPL

You have heard of the multitude of hazards that can beset your beautiful structures of wood, and you have heard of some of the "aspirins" and "band-aids" that can be used to minimize some of the adverse effects of these hazards. Indeed, some treatments can be compared with vaccinations or inoculations, offering virtually foolproof protection.

It is in this latter context — so-called foolproof protection — that I wish to address you today; first, in the general area of ground contact and then in a specific area of application — preserved-wood foundations.

One of the best preservative treatments for wood is drying to less than 20 percent moisture content, but it must be kept at less than this moisture content if continued durability is to be assured. This can often be achieved by good design and construction details, such as elevated concrete footings, damp courses between foundations and sills, and by ensuring adequate ventilation in crawl spaces and similar enclosures where condensation can occur.

A far better course of action for foundation wood or substructure wood that is in direct contact with the ground or is laid on moisture-resistant ground cover is to give it the best practicable preservative treatment, especially if it is intended to serve for the life of a permanent building. Particular attention must be paid to those out-of-sight items that tend to get overlooked. They frequently are the most susceptible to problems and are often the most expensive to repair or replace.

There are, of course, components other than foundations that require consideration. In general, any exposed load-bearing wood in a permanent building should be considered for preservative treatment.

In the United Kingdom, where those concerned with timber and its use are generally more sensitive to the possibility of wood deterioration

in service, there has evolved a system for determining the need for preservation by assessing the hazard which untreated wood would encounter. The assessment is based on the incidence of risk or damage and its potential consequence in terms of danger, cost of repair, or unacceptable inconvenience during repair. The hazard may then be regarded as the product of the risk times the consequence. Four categories for the need for preservative treatment have been defined, as follows:

1. *Preservation essential* — where timber is exposed to a continually hazardous environment and cannot be protected by design, or, where building regulations require treatment, or, where experience shows there is a high risk of failure in load-bearing structures which might constitute a serious danger to life or property.
2. *Preservation desirable* — where experience has shown there is a high risk of failure through design faults or workmanship, or, where there is a risk of attack which, if it occurs would be difficult and expensive to remedy.
3. *Preservation optional* — where there is a low risk of attack or where remedial action or replacement is simple. In such situations, the cost of initial preservation may be regarded as insurance against more costly subsequent repairs.
4. *Preservation unnecessary* — where conditions in service are unlikely to arise in which timber would be put at risk.

It may be of interest to note that one component the British consider to be in category 2, i.e., preservation desirable, is window joinery — something that receives little consideration on this continent. In view of the developing problems with cost and availability of aluminum and plastics because of the current energy crisis, wood will likely once more find increasing favor for joinery. If you have occasion to specify its use, by all means seriously consider proper preservative treatment.

Now for the specific application I mentioned earlier — preserved wood foundations, known as PWF in Canada and as AWWF (all-weather wood foundations) in the United States. The concept was first conceived and investigated in Canada 12 or 13 years ago and, since that time, has provided a history of success in overcoming the high incidence of problems with typical masonry foundations, with over 2,000 foundations built in North America by the end of 1972 and with the number increasing dramatically each year.

It is rather ironic that this system, basically a Canadian idea, still lacks full acceptance and code approval in this country, while it has had full Federal Housing Administration, Farmers Home Administration, Veterans' Administration and other lending agency approval in the U.S. for more than two years. Mortgages from these agencies for AWWF homes are not distinguished from other types of construction, either in mortgage rates or restrictive clauses.

The Farmers Home Administration is currently featuring a standard house plan with a wooden basement foundation and is advising rural families they can double their living space by using a wood foundation at a cost increase of only 5 percent over a basementless house.

For the first time in Canada, there is now a complete wood-frame foundation system for low-rise residential, industrial and commercial buildings.

The Preserved Wood Foundations (PWF) system is an extension of the familiar wood-frame construction system with the frame walls carried below grade to serve as the foundation. Currently available publications apply only to buildings up to two stories in height, plus a basement, but wood foundations may be used for taller buildings provided the foundation is designed to carry the extra stories.

A Preserved Wood Foundations Certification Board is presently being formed to examine, certify and authorize the application of the PWF quality mark to material conforming to CSA 080.15. Until PWF quality-marked material is available,

treated materials to be used in preserved wood foundations should be accompanied by a letter from the treating company certifying that the material meets or exceeds CSA 080.15 requirements.

Wood foundations started in Canada with the Mk. III and Mk. IV houses in 1961 and 1963. Mk. III is a single-story, crawl-space foundation using the space below the suspended floor as a heating plenum. Mk. IV has a full-height, wood-foundation basement also using the space under the suspended basement floor as a heating plenum.

The cross section shown in Fig. 1 is typical of a full-height wood foundation using a concrete-slab floor. The wall is similar to a regular frame

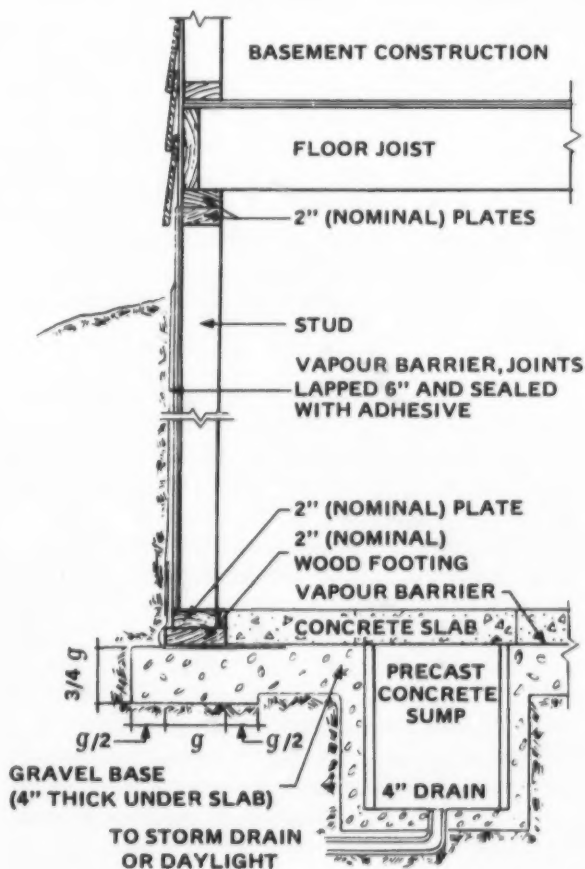


Fig. 1. Cross section of full-basement wood foundation, concrete-slab floor.

wall, using 2 x 4 or 2 x 6 studs and 1/2 or 5/8-inch plywood on a 2 x 6 or 2 x 8 footing. The pressure-treated wood using salt preservatives is clean, dry, odorless and paintable. Surface drainage is down the outside of the wall to the gravel bed, through to the sump, and is then drained or pumped to a regular storm sewer. This drainage system has much greater capacity than regular drain tiles (Fig. 2 and 3). The polyethylene film used on the outside of the foundation wall is to keep the material dry only. No hydrostatic pressure develops because of the excellent drainage and thus there are no leaks. One U.S. fabricator offers \$1,000 to any homeowner reporting leakage in one of his wood foundations.

In a typical wood-foundation installation, a bulldozer arrives on the site early in the morning and begins excavation as for any other foundation system. The first departure from the traditional foundation technique now comes with the placing of four inches of screedable gravel spread to provide under-slab drainage. Treated footings are then placed on the gravel without the use of any concrete, and water and sewer lines are laid on the gravel.

Plant-fabricated foundation panels, built on the same assembly lines as standard house panels, are now placed on the footings, with installation beginning at a corner. The panels are light enough

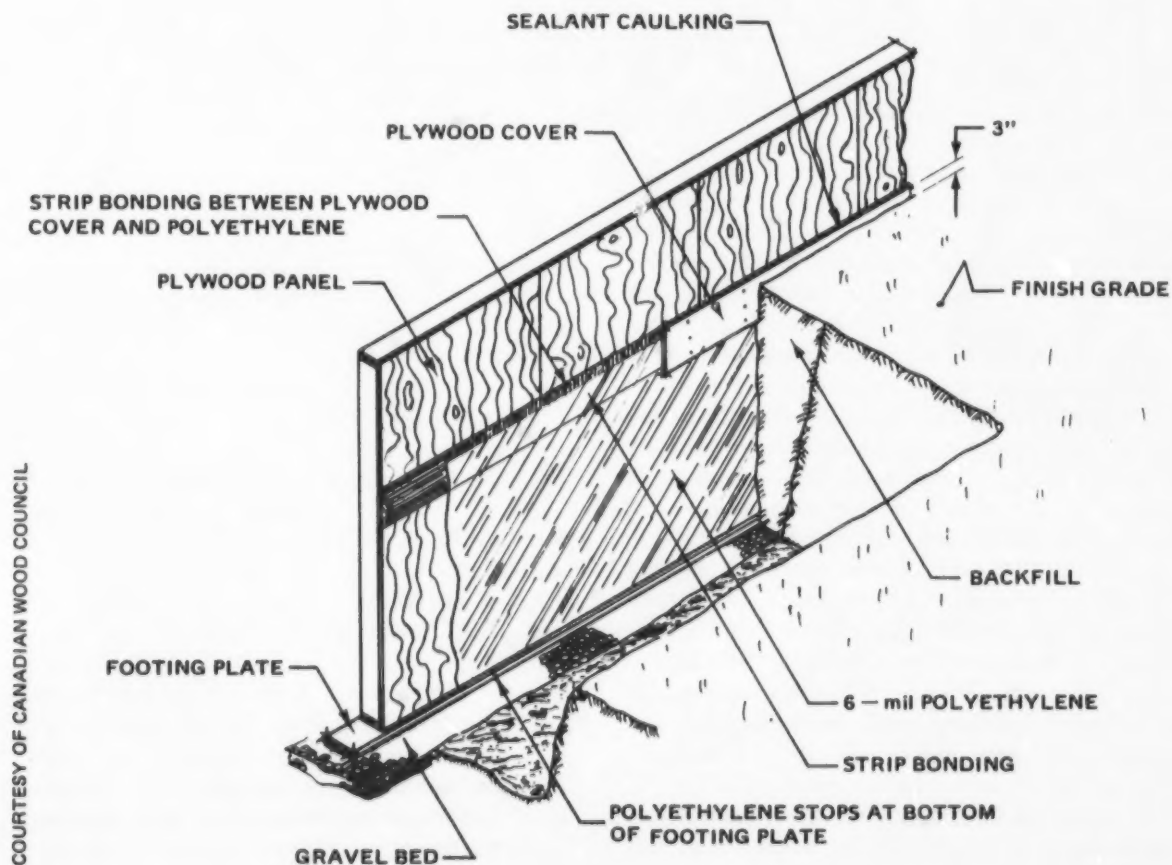
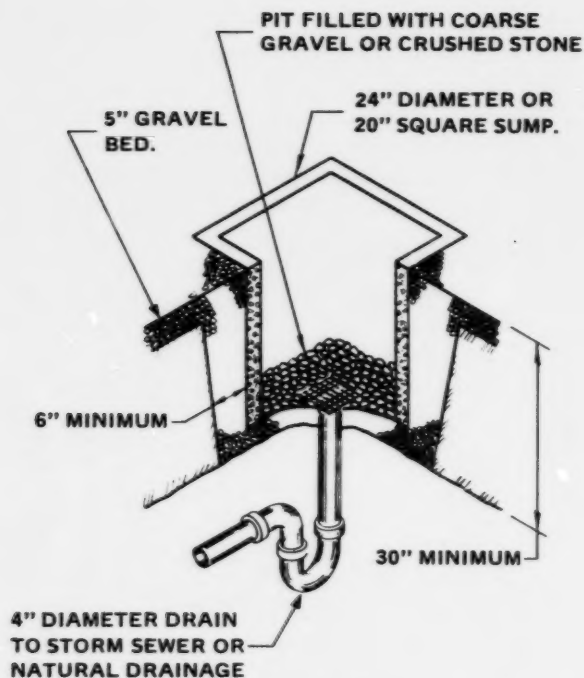


Figure 2. Sealing and dampproofing for foundation wall.



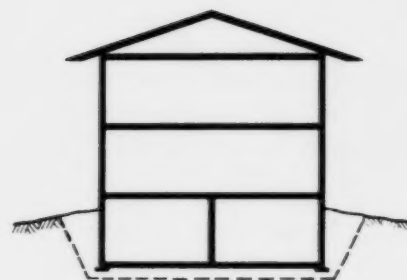
COURTESY OF CANADIAN WOOD COUNCIL

Fig. 3. Sump pit for drainage system.

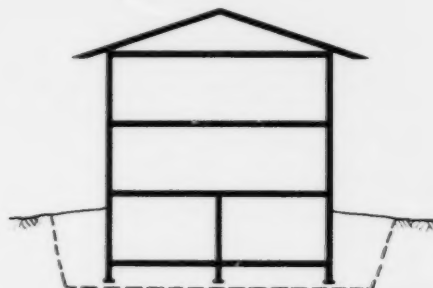
to be manhandled into position and joints are caulked on site. Final levelling and squaring of the foundation is easily accomplished after installation — something hardly possible with concrete.

Another possibility with the wood foundation is the use of the underfloor-plenum heating system as illustrated in Fig. 4. No heating ducts are required. Air blown into the plenum under the basement floor circulates through perimeter slots, first into the lower level, then into the upper level of a house and then it is returned to the furnace intake. This system provides even heat through adjustable perimeter slots at very low cost. It also provides a warm floor in the lower (basement) level. The underfloor-plenum heating system can also be used with crawl-space-type foundations.

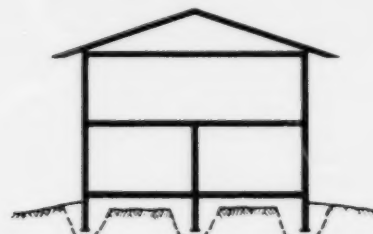
The wood foundation can be installed in a greater range of temperature extremes than can concrete. It can be fabricated in the same plant, using the same tools and tradesmen, as the rest of a house.



CONCRETE SLAB OR WOOD SLEEPER FLOOR BASEMENT



SUSPENDED WOOD FLOOR BASEMENT



EXCAVATED CRAWL SPACE

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Fig. 4. Cross section of suspended-floor plenum heating system.

RELEVANT PUBLICATIONS

Canadian Wood Council. 1973. Construction Guide for Preserved Wood Foundations. C.W.C., Ottawa. 28 p.

Alan B. Furniss, editor. 1974. MacMillan Bloedel Building Materials News 25(1): 12 — 15.

THE CONTROL OF MOISTURE IN BUILDING ENCLOSURES

Walter H. Ball, P. Eng. — DBR/NRC

1. Ground moisture

Standard practice to control the transfer of ground moisture into building spaces is now well developed. The principles involved are:

- (a) the provision of sub-surface ground drainage to prevent liquid water from accumulating in crawl spaces and other spaces below grade;
- (b) the provision of a ground seal to inhibit the evaporation of moisture from the ground into buildings;
- (c) the provision of means for ventilation, when required, of all building spaces.

2. Moisture stored in materials

Many materials, including wood, have a natural moisture content that is in equilibrium with the surrounding atmosphere. In addition to this, we often place materials, including wood, in buildings at moisture contents that are substantially above those which can be said to be natural. Design and construction details should be used which will allow excess moisture to escape, either to the inside of the building or to the outside air.

One example is in the use of relatively thick wood roof decks, where the wood is used as a structural deck and at the same time provides insulation for the roof. If built-up roofing is installed on the top or outside of such a system and the building is heated, there will be a tendency for stored moisture to follow the temperature gradient and to accumulate under the impermeable roofing membrane. If one also follows the practice of placing vapor barrier membrane on the underside of such a roof deck, a moisture trap will then be created. The trapped or stored mois-

ture will then be retained in the system and will migrate upward or downward in the system, depending on the direction of the temperature gradient. If high moisture content in the wood coincides with appropriate temperature levels, then wood rot can develop.

In this kind of a situation, it is usually best to omit the vapor barrier on the underside of the roof deck, so that the system can unload most of its stored moisture in summer. One then has to live with the possibility that some condensation of water vapor will occur within the roof system in winter. The ideal design approach would be to place the vapor barrier on the warm side of the system and then to provide a roofing system that will allow passage of stored moisture to the outside air.

3. Moisture held in the air in buildings

Air within buildings holds moisture that can create problems in the building enclosure, if it is allowed to move into and condense within the enclosure system. There are two natural mechanisms available to move water vapor into or through building enclosures. One of these is water-vapor-pressure difference and the other is air-pressure difference.

In the first case, the physical process is the diffusion of water vapor molecules through materials. This process has been recognized for many years. Water vapor flow can be minimized by the use of a material having high resistance to water vapor flow — a vapor barrier — on the warm side, or high vapor-pressure side, of the enclosure.

In the second case, the physical process is that of air movement due to air pressure differences. The water vapor, being one of the components of air, goes along for the ride and will condense as it contacts any surface which has a temperature below the dew point of the air-water vapor mixture. Control of condensation due to this process can be approached as before by the provision, in this case, of an air barrier in the system and, as before, on the warm side of the system.

It will be obvious that both functions can be performed by a single element in the system and the term "air-vapor barrier" could describe its function.

Air movement through and within building enclosures can be simple or complex. An example of a simple case is air exfiltration through cracks around windows and doors, through cracks around electrical outlets, and through joints between prefabricated panels. A more complex case is that which is commonly called "convective interchange". This usually involves a space in a building enclosure which is either vertical or inclined and which has openings near its top and bottom toward the inside of the building. As air in the space is cooled, it becomes more dense, moves downward and returns to the inside of the building through the lower opening. At the same time, air from the interior of the building moves into the space through the upper opening. The process can be continuous as long as there is a temperature difference across the air space. As soon as the outer surface of the air space is below the dew point of the air-water vapor mixture in the building, more or less continuous condensation will occur in the space.

Large amounts of water can accumulate by this means and wood rot can result.

4. Rain leakage

In order for rain leakage to occur, three conditions have to occur simultaneously. These are:

- (a) water on the exterior surface;
- (b) cracks or openings through which water can pass;
- (c) a net force to push or suck water through the openings.

If any one of these conditions is absent, no leakage can occur.

Except for situations where wide overhangs are provided, we cannot avoid water on the exterior of walls and roofs. Cracks and joints are also generally unavoidable. If they

aren't provided intentionally, nature usually takes over and provides them for us. Thus, the only things we have to work with are the forces that cause rain leakage. These forces may include capillary suction, gravity and wind pressure.

Capillary suction may act to draw water into the pore system of a material, into the space between overlapping units, or into narrow cracks in or between materials. Once filled, a capillary space has no further capacity to take in water and some additional force must be exerted on the water to force it through the capillary.

Cracks in materials and enclosure systems that are larger than capillary size can also be paths for rain entry, if they become bridged by a film of water under wind pressure, or if they slope inward and downward and gravity acts to move water inward.

Traditionally, we have dealt with the gravity flow of water through cracks or openings in building enclosures by the use of flashings to lead water outward. The recognition of the function of a suitably vented air space located inward from the exterior cladding is a relatively recent innovation. Thus, by the process of pressure equalization across the cladding, the effect of wind pressure as a force to cause leakage can be eliminated. This approach to the design and installation of cladding systems is sometimes referred to by the catch phrase "the rain screen approach to wall design", or "the rain screen approach to cladding design". Neither term is a satisfactory expression, as the requirements for enclosure design on the one hand are much more complex than is implied by the term "rain screen approach to wall design" and, on the other hand, "the rain screen approach to cladding design" should not be considered out of context with the overall design of an enclosure.

SUMMARY

By the way of summary of most of this discussion, may I propose the following simple ap-

proach to enclosure design as a basis for the control of moisture in building enclosures.

- (a) The basic enclosure should consist of a structurally supported air-vapor barrier;
- (b) Insulation should be placed outward of the structural air-vapor barrier;

- (c) Exterior cladding should be installed to create a drained, vented air space between the insulation and the cladding.

This same approach can be applied to the design of any joint in a building enclosure. Thus, we have a completely rational approach to the design of building enclosures that can provide a basis for the control of most of the sources of moisture accumulation.

THE ARCHITECTURAL OPPORTUNITIES

Alfred E. Oviatt — U.S.D.A., Forest Service

Damage due to moisture in wood structures may take many forms. We are inclined to think of decay as the ultimate hazard, because wood is an organic material and is subject to decay when its environment provides favorable conditions of moisture, temperature, and air supply. Decay organisms feed on wood substance, but, like ourselves, they can only live under very limited conditions.

When we use chemical treatments to poison the food supply of decay organisms, we effectively preserve the wood. While this may often be a necessary design measure, we should remember that we do so at a cost and that chemical preservation may not solve all of our problems in a given instance.

For example, most preservatives which are suitable for architectural work do not serve to exclude moisture from wood or diminish in any measure its effects. An exposed laminated-beam end, or arch, still suffers the effects of rain and sun, which cause wide swings in moisture content and severe dimensional stresses. Such stresses in a large section always result in checking and an unsatisfactory surface condition of paint failure or unsightly stains. Indeed, increasingly deep checks may even penetrate the treated surface regions of a timber, allowing moisture and spores to penetrate beyond and effectively bypass the treatment.

I have cited an extreme example to illustrate the point, but moisture has similar effects in smaller wood members — checking, staining, paint failure, cupping, twisting and loosening of joints. It is important for a designer to recognize these problems of dimensional change in exterior exposures, for they cannot be prevented by pressure treatment, and require other design measures to control them within acceptable limits.

I think of these as architectural problems because they lend themselves to a degree of architectural control through design and careful detailing. It follows that they are also architectural oppor-

tunities — opportunities to gain maximum performance from wood under difficult conditions.

We have learned in recent years that we must use our resources well. Let us look a little harder at wood as a design medium and some good practices, from the past and present, which can extend the performance of wood structures.

There are two simple rules for obtaining the best performance of wood under all conditions:

1. Use dry wood;
2. Keep it dry (1).

The rules are simple, but they are not always attainable. So, we must consider a third rule, but only when dry conditions cannot be maintained:

3. Treat with a suitable preservative.

We shall neglect rule 3 here, as it has been discussed by others, and consider means of keeping wood dry or, at least, less wet. This is highly desirable, of course, since we can also minimize the problems associated with dimensional changes — shrinking and swelling.

Use Dry Wood:

Green lumber from a tree has a moisture content that will support decay fungi and molds. It must be dried to between 30 percent and 20 percent to prevent decay, preferably before being placed in a building, to minimize dimensional changes. Lumber may be kiln dried or air dried, but the former is preferred because:

1. The temperature used in a kiln disinfect wood by killing any decay organisms which may have existed;
2. Better control of final moisture content is possible.

Wood should be dried to the approximate average moisture content it will attain in service. This might be an average of about 12 percent for siding, framing and sheathing in the West Coast

region, or 9 percent in arid western areas or the Canadian provinces. Fully exposed framing on the west coast may vary from 6 percent to 16 percent or more, with an average of 12 percent a reasonable compromise. Lower moisture contents are desired for interior flooring and trim.

Keep it Dry:

This must be done from a dry kiln to a completed structure, transporting and storing under cover and off the ground. Packaging is commonly used today for dry lumber and laminated beams, but also load wrapping is still employed. Often, dry lumber has been dumped without ceremony on a muddy building site. At best, it may be placed on timbers off the ground with a cover over the load. Too often, this has resulted in lumber saturated with ground moisture. A layer of polyethylene film or other moisture barrier must be placed on the ground, also.

Protection of Exterior Members:

When wood is exposed in service to the outside atmosphere, the problem of keeping it reasonably dry varies with local climate and the member's use. Temperature and rainfall are important factors. Warm weather during most of the year promotes more decay than a short, hot summer. Prolonged rains are more conducive to decay than the same amount of rainfall delivered in heavy but brief showers (1). Orientation and the presence of shade from the other buildings or trees may contribute to keeping wood wet for extended periods (2).

Critical points for moisture absorption are:

1. All exposed end-grain surfaces;
2. Capillary voids between two surfaces;
3. Connections;
4. Pockets, splits and checks in side-grain surfaces.

Previous generations of designers have provided us a legacy of thoughtful detailing in wood.

We need only look around us at many of the Victorian structures of the west to find much that has been skillfully designed and executed. But lessons that were learned generations ago often escape us in our haste, leaving us to re-think the same old problems over again.

An outstanding example from the past is the covered bridge, many of which remain in our states and provinces. The use of a complete enclosure to shed rain and cast shade on the critical structures of these bridges provides a common-sense example, which may be profitably imitated in varying degrees. Cover for wood construction may take many forms, such as the wide overhangs found in many western buildings which effectively protect structure, siding, sash and trim from frequent wetting and the high sun. Flashings and covers, limited to vulnerable surfaces or joints, are effective protective devices when properly detailed and applied. These may be of metal, wood, plywood or even plastics, and may be either decorative features or blended to match wood surfaces. An example which comes to mind is the use of neoprene-hypalon covers on the exposed ends and tops of glued-laminated beams in the Forestry Building at Oregon State University. Wood granules are imbedded in the top coating and stained to match the beams.

The use of covers can be very effective in protecting wood from the weather, but it's a little like saying, "When you are inclined to use wood fully exposed to the elements, don't". While it is a sound rule, it doesn't give us much room to maneuver. In fact, wood structures can be successfully designed to minimize the effects of weather to a very great extent. Following are some of the means which have been successful in providing fully exposed structures of long life:

1. Slope end-grain surfaces away from direct rain and sun exposure. Cap the ends of posts and other verticals. Seal all end-grain wood, including mitres, by dipping five minutes or more in a water-repellant preservative. Brush flood all fabricated ends and holes with the same. This type of treatment is most effective on end-

grain surfaces, where it penetrates deeply enough to seal against water.

2. Provide natural drainage and allow for air circulation. When joints or other details are designed to shed water and to permit rapid drying after a rainfall, the duration of conditions favorable to decay can be greatly lessened. Slope railings, stairs, the tops of deck stringers or joints. Avoid capillary voids which retain water. Space butt joints in railings and decks to allow air circulation.
3. Use wood grades and species which stay in place well. Clear grades with limited slope of grain, if obtainable, are best. Species such as western red cedar, redwood, spruce, poplar, and the soft pines are stable. Choose sections which are more nearly square rather than thin, wide boards; for example, a 3" x 4" instead of a 2" x 6" or a 1" x 8". Use quartersawn or edge-grain lumber, if available.
4. Fasten assemblies well with rust-resistant fasteners or waterproof adhesives.
5. Use heartwood of a decay-resistant species for maximum durability in the weather. Western red cedar, plentiful in British Columbia, is an excellent choice for permanence and stability. Redwood and the light cedars found in the west are also good choices on both counts. The heartwood of any species, such as Douglas-fir, is more resistant to decay than the sapwood, although less so than the species named above.
6. Well-designed and *well-maintained* finishing systems, with prior dipping of all ends and fabricated surfaces in a water-repellent preservative can extend the performance of exterior wood by slowing the rate of moisture penetration. Surface coatings, however, depend heavily on the effectiveness of end seals, since water absorbed in end grain will eventually

loosen or blister coatings. There is a trend today toward penetrating stains in preference to paints, since they are much easier to maintain. However, they do not retard moisture passage as effectively as paints.

The essence of good performance in any finishing system is adequate maintenance, which is all too often neglected.

I have referred several times to the use of a dip treatment for the protection of ends and points of fabrication. I recognize in this connection that many treating authorities regard anything less than pressure treatment as generally ineffective and a waste of time. This is because penetration in side-grain surfaces is very limited without pressure.

However, the end grain of dry wood is highly absorbent, and does absorb an oil-borne solution to significant depth, just as it will readily absorb water. Such a solution fills the wood cells, but does not enter the cell walls and does not cause the wood to swell. A water-repellent solution can thereby exclude water where the wood is most vulnerable. Research by the U.S. Forest Service strongly supports the value of this kind of treatment for constructions where pressure treatment may not be justified or available.

A water-repellent preservative usually consists of a 5 percent pentachlorophenol solution in a light oil, like mineral spirits, with paraffin added to shed water. Some commercial preparations are available, or a capable painter can formulate one. Where stain is to be used, it can be incorporated in the solution as a pigment and the entire surface coated. Water repellents do require frequent maintenance on surfaces to maintain repellency, but end-grain areas remain sealed for a much longer period.

In summary, it may be said that pressure-preservative treatment is indicated in most cases for such wood elements as exposed primary structural framing, like glulam columns and arches. Also, members imbedded in or in contact with the ground, or other framing subject to excessive wetting and costly to replace may require treatment.

Treatment is not a substitute for good design. An architect has an opportunity to improve the performance of exterior wood elements, whether treated or not, by minimizing exposure to moisture and its effects.

Many exposed constructions of wood can be so designed that adequate performance may be expected without the use of pressure treatment. Such light structures as exposed wood decks above the ground, covered walkways and screens are examples. The choice of such treatment by the designer may depend upon the availability of treatment and upon the cost-benefit relationship, a factor which will vary with climate and design.

REFERENCES

1. T.C. Scheffer and A.F. Verrall. 1973. Principles for Protecting Wood Buildings from Decay. U.S. Forest Service, Research Paper FPL 190, Madison, Wis.
2. Edward W. Schein. 1968. The Influence of Design on Exposed Wood in Buildings of the Puget Sound Area. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

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